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Design, Analysis and Manufacturing of Front Wheel Assembly of Formula Student Race Car

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ABSTRACT

The purpose of Formula SAE is to provide students an opportunity to design, fabricate, and thendemonstrate the performance of a prototype race car. This project focused primarily on a major redesign of the previous Formula SAE car by determining its strengths and weaknesses.The areas addressed for improvement include the chassis, front suspension components and geometries, tuning transmission ,the air intake, exhaust system, engine mounting, fuel tank, braking components, and the uprights for the front suspension. With weight reduction in numerous systems of at least ten percent, analytical design of the intake, exhaust, and front suspension, and increased height of the chassis roll hoops and length between the front roll hoop and bulkhead, the final product is lighter, more efficient, and provides more room and comfort for the driver than its predecessor.

Keywords: uprights, hub, bearings, caliper, brake pads etc.

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1. INTRODUCTION

The upright connects the control arms to the hub which connects the upright to the wheels,allowing the vehicle to move. The uprights also connect to the steering arm, allowing the driver to steer the vehicle, and the caliper, allowing the driver to stop the vehicle. The hub is directlyconnected to the wheel, and is connected to the upright. The upright is to remain stationaryrelative to the chassis while the hub is to rotate with the wheel. This is done by placing a bearing between the hub and upright. Typically a spindle is pressed into the upright and does not rotate
and a bearing is pressed into the hub, and the spindle is pressed into the bearings allowing the hub to rotate about the spindle.Unsprung mass is the mass of the wheel, hub, rotor, caliper,uprights, and brake pads.Essentially unsprung mass is the mass that is not supported by the shocks (for example the chassis and everything supported by the chassis is sprung mass).

1.1 Literature Review

Upright is a part of the wheel assembly which holds the hub and allows rotation of the wheel. The forces from the tire contact patch are transmitted by the upright to the suspension links. The suspension geometry of a standard FSAE race car has been used for the calculation of the forces. The target values for concerning and braking have been set according to the tracks present in the FSAE International events. Tire data has been used to find out the friction coefficient at the contact patch which varies to the normal load on it.[1]

The goal is to produce a lighter and performance oriented design of upright assembly in comparison with previous car and thereby contributing in making of car of next season better than its predecessor. Use of conventional upright assembly will increase the overall weight of race car. For FSAE car, weight criteria is a main factor in making of race car and as well as competition point of view. The goal of lighter weight upright assembly can be achieved by less complex design and proper material selection. Also the proper stiffness and reliability can be achieved by analysis of design of upright assembly.[2]

While designing and developing any automobile the designing of the wheel assembly is critical. It is due to the reason that a lot of forces are acting on the wheel assembly during accelerating, braking, cornering and tilting. Furthermore, the Wheel Assembly is an important part of an automobile and its failure is hazardous endangering human life. Therefore is required to design the Wheel Assembly and its components considering all the factors leading to the failure by developing a safe Design. It must also be noted that, the components must be designed in such a way that they have a minimum weight at the same time care must be taken that they do not cross a certain limit of stress value Optimization has been carried out by doing analysis of the components in Hyperworks.[3]

1.2Objectives and Scope

1] Reduce unsprung mass.
2] Must be the sole component in resisting forces in torsion and bending.
3] Lightweight to maintain good performance to weight ratio of the race car
4] Ease of maintenance for enhancing serviceability and setup repeatability
5]And for the purpose of this team, ability to manufactured the components in-house to reduce turnaround time and outside dependability.

2. THEORETICAL DESIGN

1) Model loading:
The loads applied to model are based on the data collected in the previous years from the vehicle data acquisition system. The system records the maximum cornering force and this information is used in conjunction with the vehicle layout and weight distribution to determine the forces on the front and rear tires.
For the cornering scenario, a lateral force (model y-axis) 1.2G is applied to the front upright at the contact patch centre, along with a 800lbf of combined bump and lateral weight transfer caused by the lateral acceleration of the vehicle, applied to the vertical direction at the contact patchcentre (model z-axis).
2) Model constraints:
The upright model is constrained at the upper and lower ball joint plus the steering/rear toe pickup points. Since all the joints are made with spherical bearing, they do not offer any resistance to moment; their rotational constraints are all left to be free. For the lower ball joint on the race car, it is connected to the lower arm and also the pushrod. Under load, the a-arm will resist the movement in lateral and longitudinal direction, while the pushrod will resist the load in the vertical direction. Therefore the lower ball joints are constrained in the model in the displacement in x, y, and z axis. For upper ball joint, since there are no pushrod connection, itresists movement only in longitudinal and lateral direction, therefore it is assigned with constraints in x and y axis. For the steering/toe-link pickup, the only link that connects to this joint is either the steering link or toelink. They only resist movement in the lateral direction, so only y-axis is constrained in the model.
3) Model Stress:
The FEA package allows for the computation of stresses in different ways, the stresses can be represented in principle stress, component stress, or Von Mises stress. Since it is important to know the yield and material limit, as well as the computation of safety factor, Von Mises stress is used in presenting the stress results. The FEA results are compared against the fatigue strength of the material corrected for a known service life. The correction factors followed that of a standard fatigue calculation and takes into account of load factor, size factor, surface quality, operating temperature, and reliability.
4) Optimization parameters:
The deflection of the upright assembly will be the basis for the optimization process. With stiffness being the performance standard and weight being the concern, the design goals are defined to be reduction in weight of previous car with comparable stiffness. To optimize for weight, thickness for different faces of the upright are changed iteratively based on the previous run's stress distribution and deflection value, thematerial thickness were reduced in the areas where stresses are low. The limiting factor being stresses cannot exceed the material limit. With available thickness value based on available stock material, a number of combinations were analysed and the optimum front and rear upright designs were selected as the final designs.
5) Results:
The finalized designs and their associated FEA results are as per our requirments. Knowing the aforementioned issue with FEA results, interpretation in the boundary region of the mating edges between solid and shell element, the focus then is on the region that's around the boundary. As such, the stresses in those region combined with calculated endurance limit resulted in the fatigue safety factor of 3 for the front. The value may sound to be too risky, but knowing the conservative estimate for the fatigue cycle, as well as the actual joint design being more robust with multiple weldments, these values should be more than adequate.
Based on the FEA model, maximum deflection of the upright assembly based on the given loading condition for cornering and bump is 0.0021", which is better than 0.005" of 2016 design. The gain can be contributed to the closer proximity of the bearing support housing to the outer perimeter of the upright body, since this where the maximum deflection occurs. The resulted design also weighs less in the model from than the 2016 design, due to the material reduction in the less critical area along the upper ball joint.

The following is the given component which is to be manufactured:

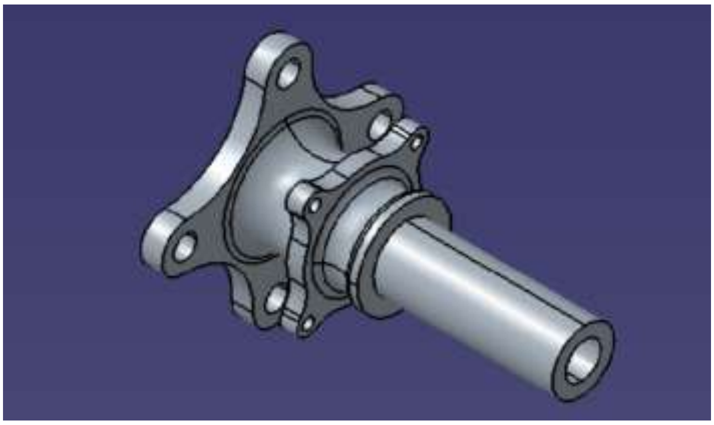

Fig-1: Component Drawing of Hub

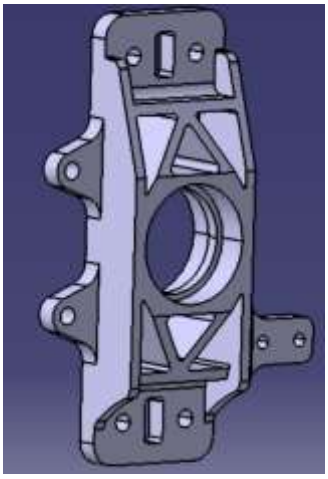

Fig-2: Component Drawing of Knuckle

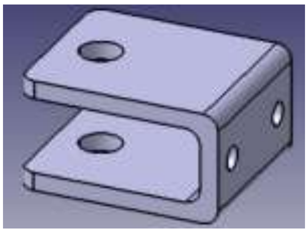

Fig. 3:Upper, Lower & Steering arm shim

Design procedure:

The first step while designing the wheel assembly is to find out the required parameters in order to design the wheel assembly from the steering and the suspension geometry. The Steering and Suspension Engineer design their geometry, a kinematic representation of various parts in that system, according to the requirement. A Wheel Assembly Design Engineer must refer to these geometries so that in the actual car these parameter are followed. The Steering Geometry has an influence on the Front Wheel Assembly only. The Front Suspension and Rear Suspension Geometry affect the front and rear assemblies. Parameters such as King Pin Angle, Steering Arm angle, Tie rod angle are obtained from the Steering geometry, whereas the Caster angle, the

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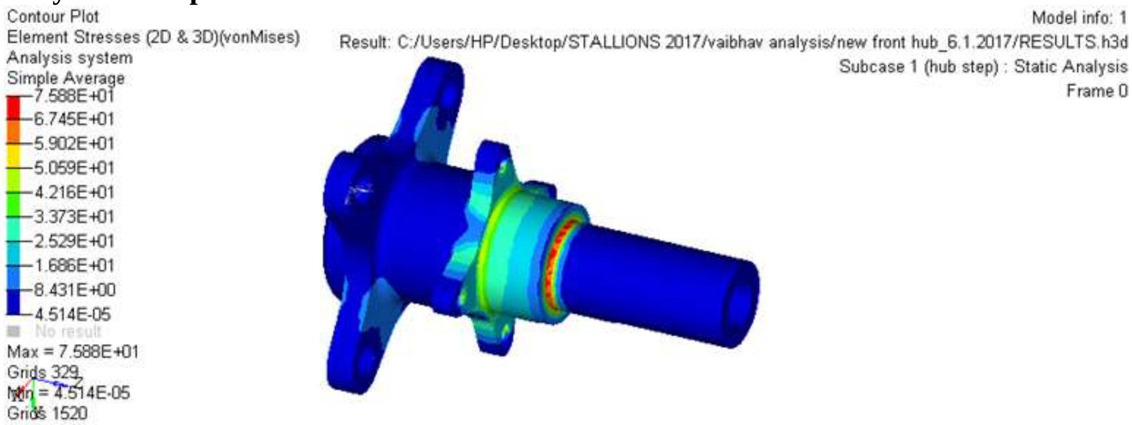
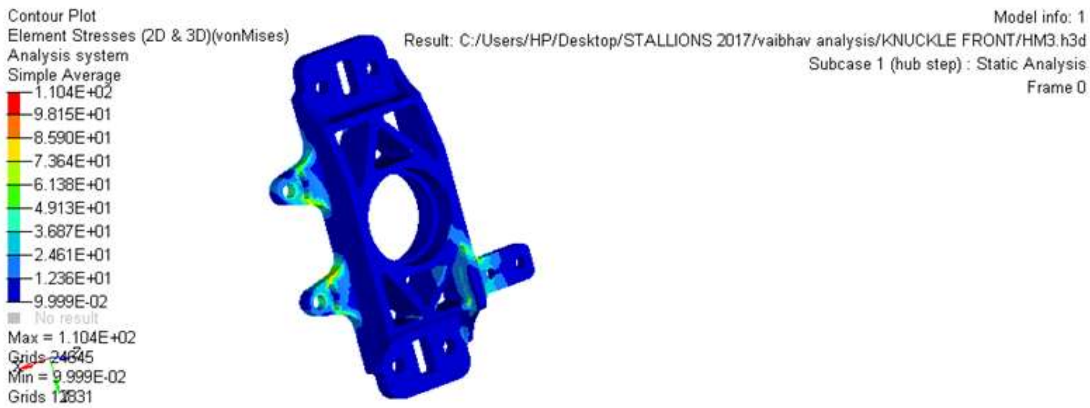
angle of upper A-arm and the lower A-arm, Rear Track width are obtained from Suspension Geometry. Parameters like the Stub length and the front track width are obtained from both Geometries.

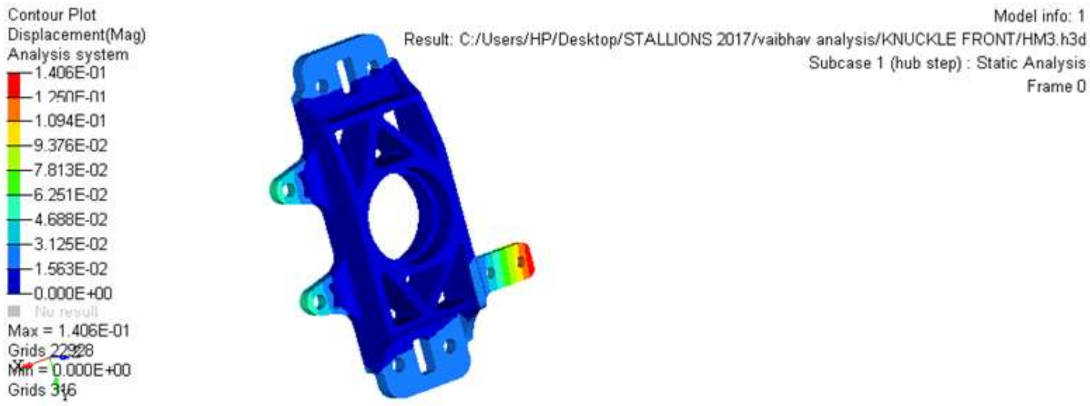
Formulae for finding different parameters:

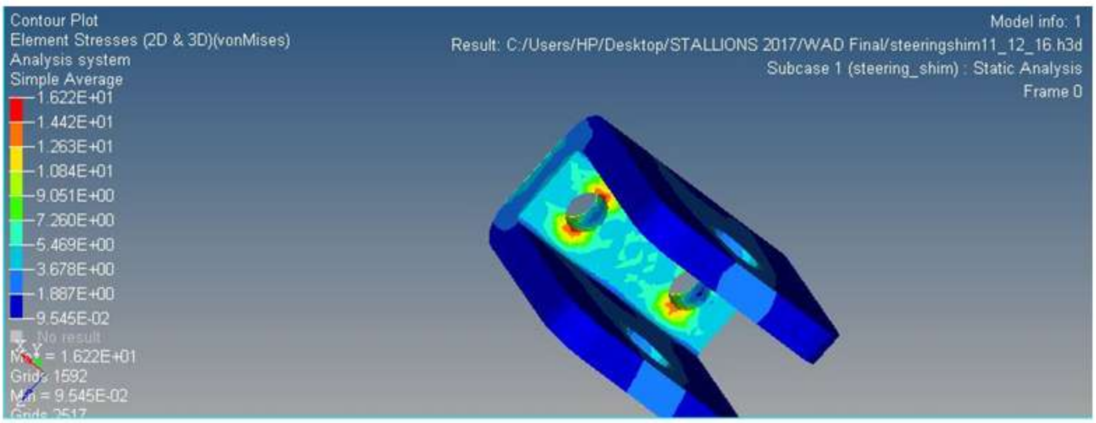
1] Bump × Travel due to bumpForce = Wheel rate
2] Shear stress = Force/ resisting area
3] Torque = mass on the spindle × g × radius of the wheel × coefficient of friction

Analysis of components:









Manufacturing-

By studying various material properties, for front hub we selected EN24, for knuckle and for upper,lower and steering shims we selected AL7075.

Sr no.	Part	Selected Material	Machining Processes	Various machines used	Total duration of machining in hrs
1.	Hub	EN24	CNC turning, vertical surface milling.	CNC lathe , VMC	4
2	Knuckle	AL7075	Vertical machining and surface milling , wire cutting.	VMC, DRO, wire cutting	6
3	Shims	AL7075	Milling	VMC , Surface milling.	2

Conclusion:

The purpose of this thesis project is not only to design and manufacture the upright and hub assemblies for the2017 Formula SAE car, but also to provide an in depth study in the process taken to arrive on top. FEA model form the design seems to be a step forward from the design of 2016.With the overall design being carefully considered beforehand, the manufacturing process being controlled closely, and that many design features have been proven effective by the 2016 design, the 2017 uprights should be well within the performance requirement of the vehicle. In terms of quantifiable improvements, the 2017 design illustrates a significant weight reduction over the 2015 and 2016design.On the 2017 vehicle, with the same level of deflection compare to the 2016 design in the FEA. Although actual gains cannot be seen until the vehicle hits the track.

REFERENCES:

1]Designing and Optimization of Wheel Assembly of a Formula Student Car by JoijodeVrushabhUmesh and Yadav Abhishek †Mechanical Engineering Department, Vishwakarma Institute of Technology, 666, Upper Indira Nagar, Pune-37, India.Accepted 02 March 2016, Available online 15 March 2016, Special Issue-4 (March 2016)

2] Design and Analysis of Hub and Knuckle of FSAE Race Car by
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